A REVIEW OF AIR RECEIVER CASUALTIES WHERE THE COMPESSOR HAS BEEN MOUNTED ON THE RECEIVER

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The National Board of Boiler
and Pressure Vessel Inspectors
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THE NATIONAL BOARD OF BOILER AND PRESSURE VESSEL INSPECTORS

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PREAMBLE

The National Board of Boiler and Pressure Vessel Inspectors was organized in 1919 and is devoted to safety and uniformity in the use of boilers and pressure vessels. Its members are officials in governmental jurisdiction who are engaged in the application of safety rules and requirements. Its growth and success in accomplishment are due, undoubtedly, to the precept to which it has adhered i.e., that uniformity in administration of safety rules and regulations is of importance equal to the task of formulating such rules. The National Board's operating basis is to be found in a statement of purpose and objectives that forms the Preamble to the National Board Constitution which reads as follows:

OBJECTIVES OF THE NATIONAL BOARD

(a) To promote uniform administration and enforcement of boiler and pressure vessel laws, rules and requirements.

(b) To promote standards for acceptance of boilers, pressure vessels, parts and appurtenances to assure safe operation.

(c) To promote one uniform Code and one standard stamp to be placed on all registered boilers, pressure vessels, parts and other objects constructed in accordance with the requirements of that Code.

(d) To promote one standard of qualifications and examinations for inspectors who are to enforce the requirements of said Code.

(e) To gather and make available, information and statistics useful to the members, inspectors, and others interested in boiler and pressure vessel safety.

FOREWORD

Over the past few years the National Board has been receiving complaints from various jurisdictional authorities regarding explosions of Air Receivers.

Photographs and accident reports that have been forwarded to the National Board indicate that the majority of the explosions of Air Receivers are due to insufficient reinforcement where the air receiver is mounted on the vessel causing cracking and as a result, ultimate explosions or rupture of the vessel.

The National Board has taken this matter into consideration and suggests that the air receiver be separated from the compressor with the compressor mounted separately on the floor or other suitable means and **not be mounted directly on the air receiver.**

DISCUSSION

The incidence of violent crimes in the streets of our cities, highway accidents, industrial injuries — all these things and more are of deep concern to all of us. United action to achieve greater protection for our citizens under the laws of the land are a never-ending goal toward which we all strive.

Looking at our own specialized area of public safety, statistics gathered over a span of years show that we have a problem which persistently keeps recurring and stands out above most other problems in the number of casualties incurred. Contrary to what we might expect, this problem area is not related to boilers. Every political subdivision in the United States and Canada with any interest in the safety of its citizens has a Boiler Safety Law on its books backed by some measure of enforcement. With the ASME Code as a universal standard, uniform enforcement of design, construction and inspection is a near reality so far as boilers are concerned.

Our problem area is in pressure vessels, a field that unfortunately, all too many of our jurisdictional laws do not cover. In this treatise we want to discuss just one segment of the total field of pressure vessels, air storage tanks or air receivers, whichever you choose to term them.

The National Board has received many reports from jurisdictions and insurance companies regarding violent rupture of air tanks, in particular those with top-mounted reciprocating air compressors and with legs or cradles welded to pressure retaining surfaces of the tank. The State of California alone reports two hundred and fourteen (214) cracked or ruptured air tanks over a six (6) year period, 1970 through 1975, and we have to wonder how many others were not found or reported. The California jurisdictional authorities are seriously considering administrative action under state rules and regulations to require removal of compressors from mounting on top of the tanks.

The State of Arizona led the way in 1975 by amending their Boiler and Pressure Vessel regulations to prohibit the mounting of compressor units on air tanks with the exception of those tanks which could be proven to have been specifically designed for this type of service, giving due consideration to stress-strain forces resulting from kinetic energy of tankmounted compressors.

What the Arizona regulations are saying to the producers of these combination compressor and air tank units is simply "Look friend, read Article UG-22 of the ASME Code and comply with it".

The above mentioned Code Artcle requires the tank manufacturer to provide design allowances for loading such as legs, saddles and other types of support as well as superimposed loads from operating equipment such as the aforementioned compressors. The troublespot here is that in most cases the vessel manufacturer fabricates an acceptable Code vessel which he sells to the assembler of the air compressor-tank unit. The tank manufacturer has no real control over what happens to his tank once it goes out his back door. The assembler can take this Code tank, weld a saddle mount for a compressor onto it, weld legs onto it, all very possibly without the services of Code qualified welding procedures or welders and with no regard to the kinetic stresses involved. He then markets this potential bomb, pointing proudly to the ASME Code air tank (which he has just destroyed) as a guarantee of quality for his product.

The foregoing is of deserved concern to many tank manufacturers who maintain a high standard of quality control and faithfully believe they are fulfilling ASME Code requirements. At least one air tank manufacturer we know of requires a review of his customer's ultimate use of the vessels and offers to install load-bearing attachments at cost, prior to sale. In this way his own engineers can compute expected stress loadings and build the air tanks accordingly. In addition, a metallic warning plate is affixed to each air tank stating that any further welding applied to pressure surfaces may result in cancellation of the manufacturer's guarantee, the ASME Code stamping and National Board registration. Reports from this manufacturer indicate that these actions have contributed toward a reduction in tank failures and enhancement of this manufacturer's reputation. Here is an example of excellent compliance with Article UG-22.

ASME is taking cognizance of the situation and it is hoped that proposed changes in the Code will help alleviate present intolerable conditions to some extent. The ASME Code is for new vessels. It defines minimum acceptable standards of construction and gives due warning that service conditions beyond those normally encountered must receive consideration by the designer.

We firmly believe that the root of most of our troubles is insufficient attention being given by many manufacturers to the requirements contained in Section VIII Division 1 under Para UG-22 and Appendix G.

Some measure of help might also come from the Authorized Inspectors who service those facilities manufacturing air tanks. Subarticle U-2 (g) definitely gets the Inspector into the area of added design detail and construction. Para UG-22 requires consideration of additional loadings and Appendix G sets forth good practice regarding design of supports. Other pertinent references are UG-54 and UG-55. At least the Inspector's inquiry

into these points will make the manufacturer's design people more cognizant of their provisions.

We have been addressing ASME Code vessels thus far and most certainly the continued integrity of the ASME Code symbol stamp is of prime importance to all of us; but the state, provincial and municipal jurisdictions have an added problem which is even acute. We are speaking of critically unsafe non-Code air tanks. The recipe for this piece of cake is to use a non-Code material of lesser thickness than the Code limits, weld it as cheaply as possible with unproven procedures, unqualified welders, weld a compressor mount and legs on it with no inspection for quality and put it on the market for an unsuspecting public to buy. The end product is not only a bomb but a bomb with the fuse already sputtering.

A moot example is the case of a manufacturer in the State of Arkansas who was producing non-Code air tanks fitted with non-Code relief valves which were adjustable between 160 and 250 psi at the whim of the user, the upper seting being well beyond the hydrostatic test pressure. Only one out of every ten tanks was hydrostatically tested. Welding on these tanks was a disgrace. The Chief Boiler Inspector of the State of Arkansas proceeded with legal action against this manufacturer, meantime learning of nineteen (19) recorded explosions of these air tanks in various states which included severe injuries to personnel.

Through the blessings of a strict Pressure Vessel law in the State of Arkansas enforced by an alert Bureau of Boiler Inspection and with full cooperation of other State agencies, the citizens of that state plus other jurisdictions who had enforceable Pressure Vessel laws were protected from the hazards of such products as those described.

The sad part of this tale is that the offending manufacturer simply moved his "air tank" plant into an adjoining state which has a Boiler Law **but no Pressure Vessel Law** and he continues to produce a line of non-Code air tanks, shipping them and selling them in jurisdictions where the public is NOT protected by Pressure Vessel laws.

The moral of the foregoing should be clear to all.

National Board has a multitude of accident reports on file, all quite similar in nature, involving Code and non-Code construction. Certain trends are evident and can be stated as follows:

(a) Almost without exception the air tank failures involved fillet welds at support attachments, ie: compressor mounting saddles, leg or hold-down attachments.

(b) Time of failure is indeterminate ranging from a few months service up to many years.

(c) Most failures involved undercut of the base metal in the vessel wall but this was not necessarily true in all cases.

(d) Almost without exception failures were in tanks which received kinetic stresses from reciprocating air compressors mounted on top of the tanks. A further general trend shows rise in failures in proportion to H.P. of the motors driving the compressors. This simply reflects greater stresses imposed upon the tank by weight and vibration of the larger compressors involved.

(e) Shell failures are appreciably reduced in areas of base attachments when saddles extending over at least one third of the Vessel circumference are used (see Section VIII Div 1 para UA-190). Circumferential welding **only** is recommended for saddle attachments of base plates or legs. Longitudinal welds should be avoided.

(f) Spring loaded vibration dampeners under the legs of air tanks are a help but not a cure-all.

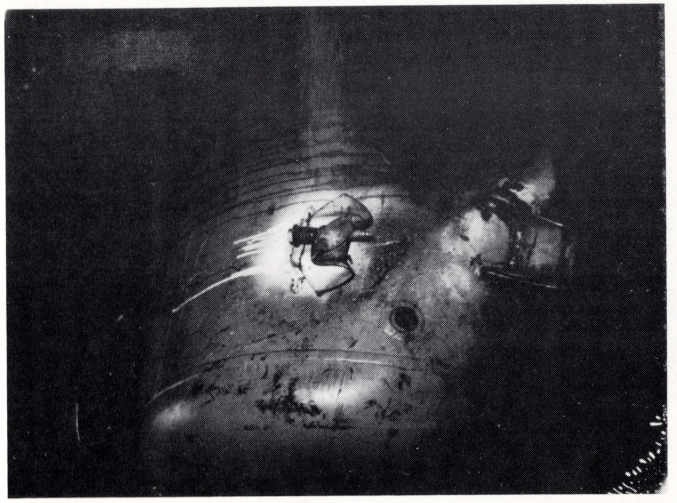
(g) Although information is incomplete in some cases, those recorded indicate casualties to non-Code air tanks out number those to Code air tanks by close to a 4 to 1 margin.

From the manufacturer's standpoint, design of a vessel must be based on the end use to which the vessel will be subjected. This, in essence is what UG-22 is saying. It is essential to know where the vessel is to be installed, in what service it is to be used and whether it will be subjected to stresses due to cyclic operation. Interaction of supporting attachments and loading must be known. Only if the above are considered can the vessel designer carry out his Code responsibilities.

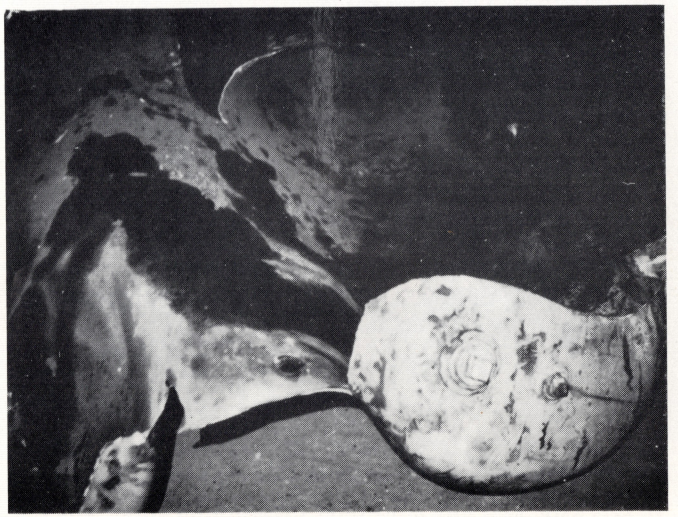
As previously referenced, many states and municipalities have Boiler Safety Laws with adequate enforcement agencies to carry out those laws. It is hoped that examples and pictures presented here may encourage those jurisdictions NOT having Pressure Vessel Laws adopting Section VIII of the ASME Code to make renewed efforts to afford the citizens of their jurisdiction the protection of such laws.

Following are a sampling of pictures from the National Board files illustrating a few of the points we have been discussing.

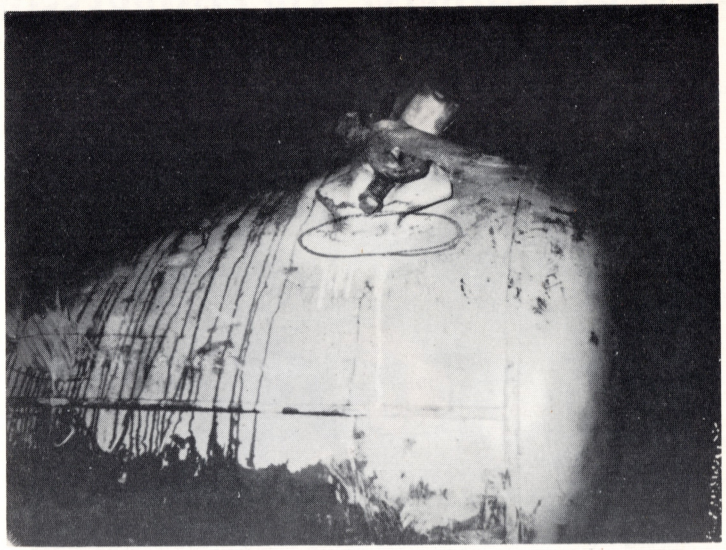
PICTURES SHOWING AIR COMPRESSORS WITH COMPRESSOR MOUNTINGS



Note: It appears that aditional weld was applied to leg and then the weld was painted to prevent corrosion.
All four (4) legs had been rewelded.
The compressor had been mounted on this vessel.



Vessel's present condition after failure.

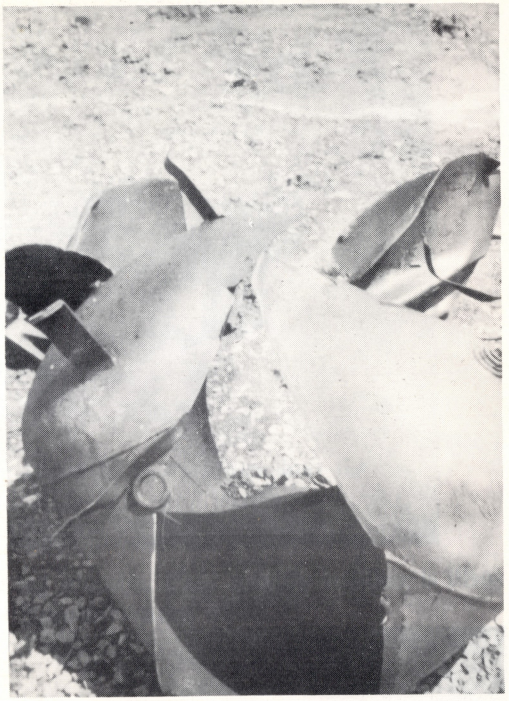


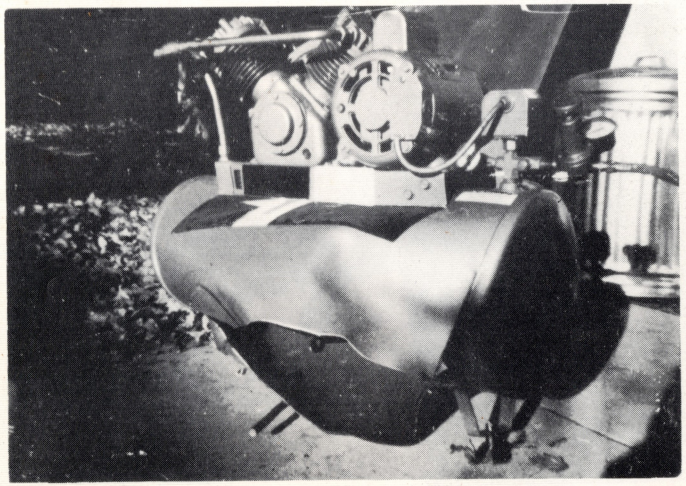
Long seam is intact, failure was 90° from long seam. Again note additional weld to leg area.

Area marked is where a leg had been rewelded. Note weld material on shell.

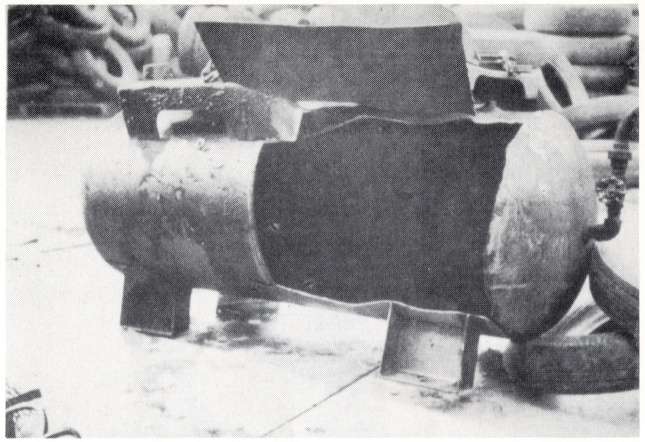
Ruptured Air Tank.

A bomb with the fuse lighted!

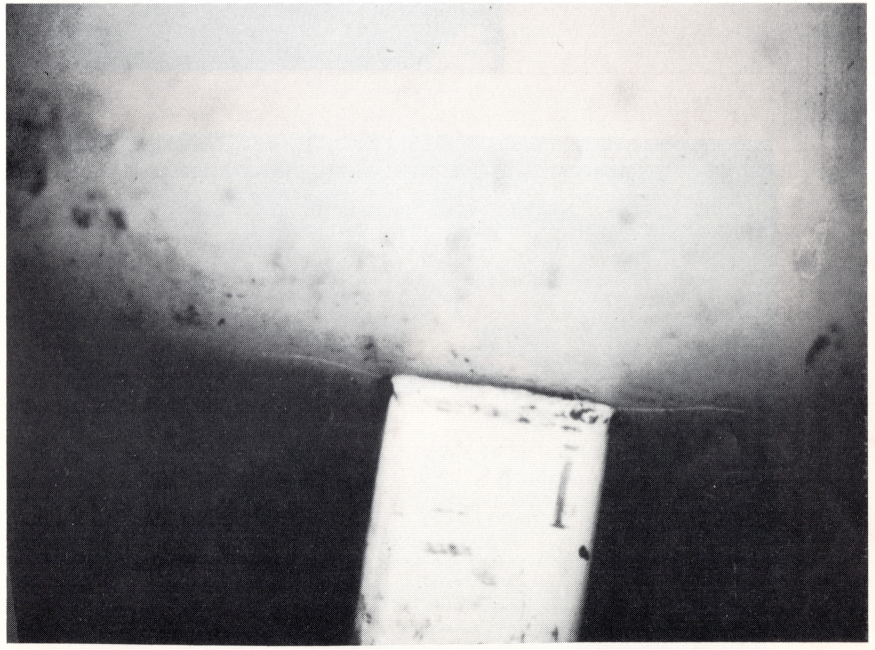




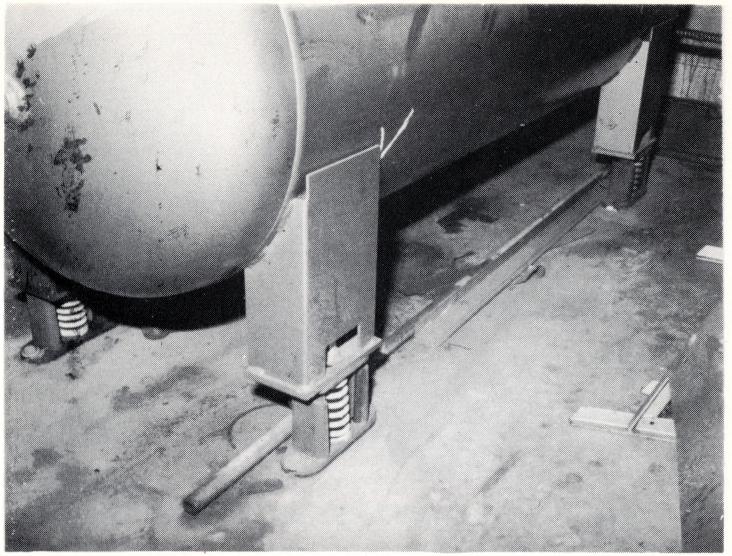
Ruptured Air Tank. Note compressor mounting and legs, also size of motor and compressor.



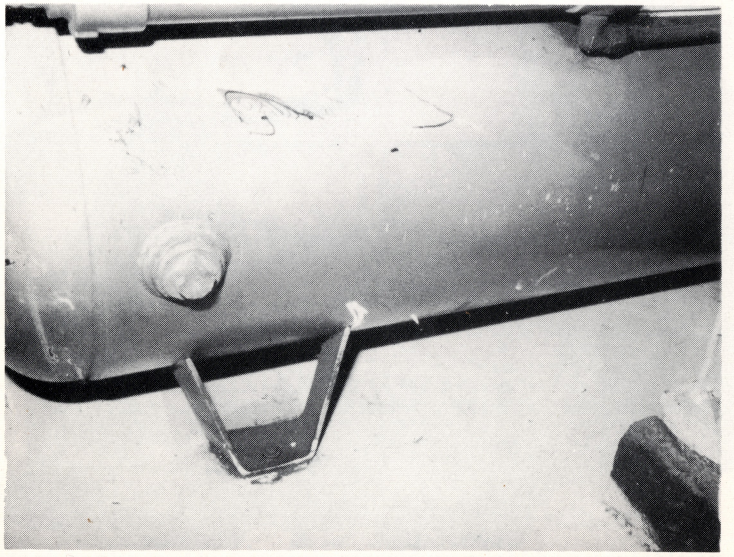
Air tank ruptured as result of improper mounting.



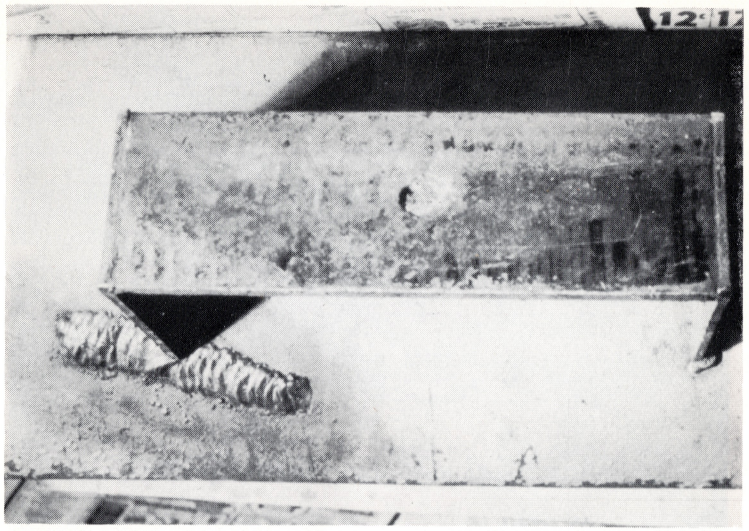
Note crack from leg mount into shell, also longitudinal weld of mount to shell. Mount or leg welds should be limited to circumferential welds only.



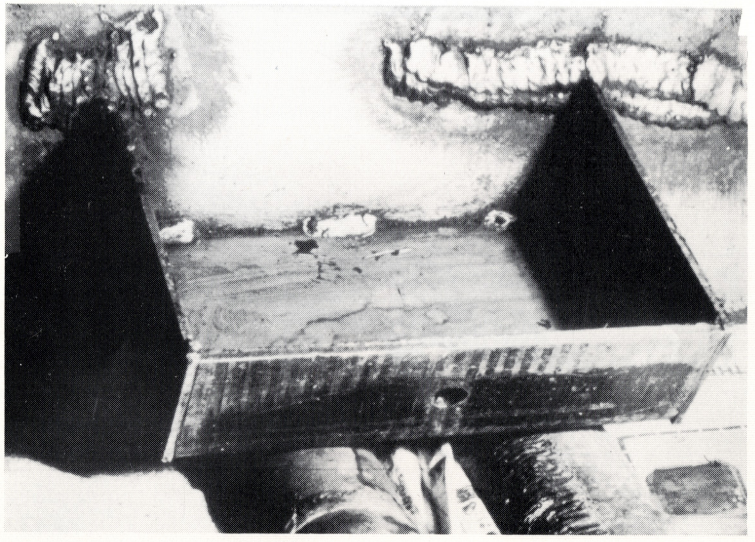
Compressor showing cracks at leg mounts. Poor quality welding is disastrous in either longitudinal OR circumferential welds.



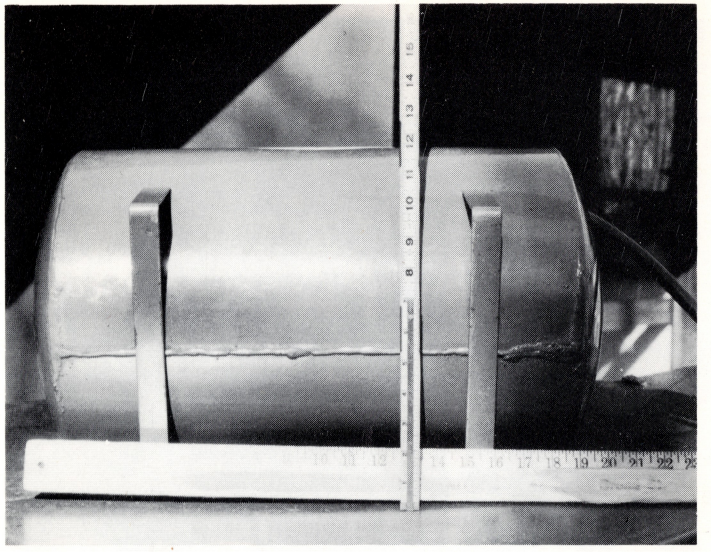
Compressor showing cracks at leg mounts. Method of leg attachment does not comply with UA-190 Section VIII of the Code.



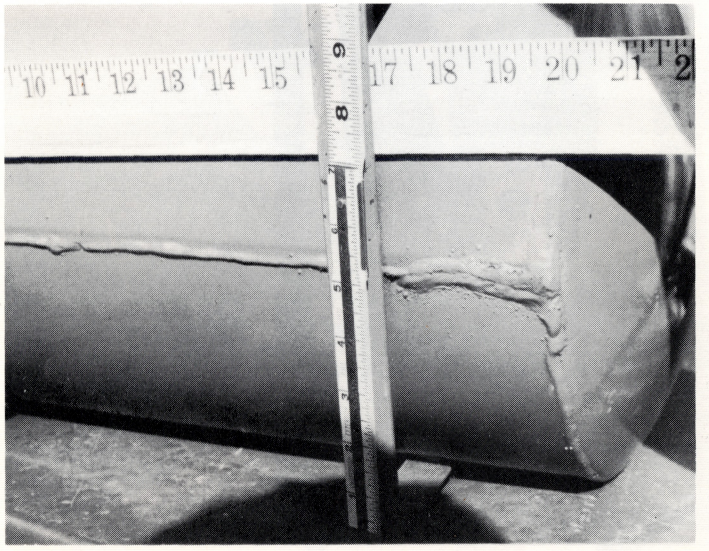
Compressor mount welded to shell — cracks occurred from mount to shell. Picture shows weld repair



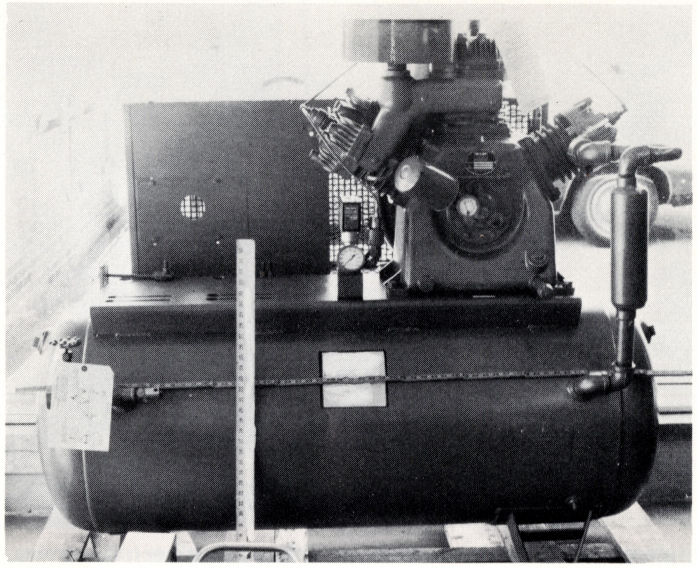
Picture shows cracks originating from compressure mounts — note weld repair of crack.



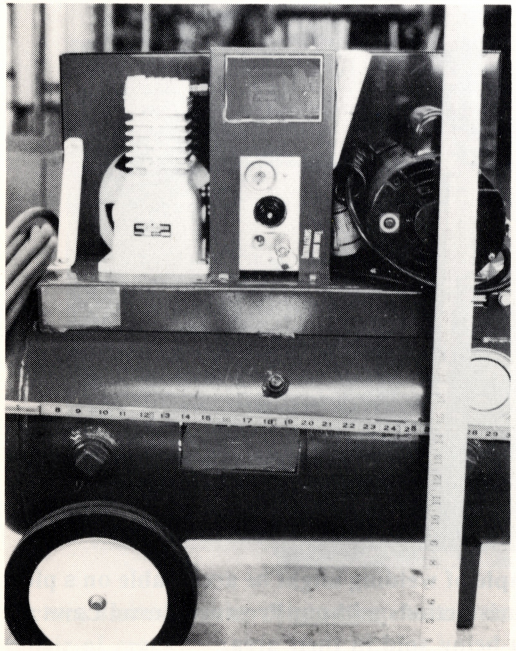
An example of a non-Code air tank, new, has never been in service. Would you want to be near it when it was pressurized?



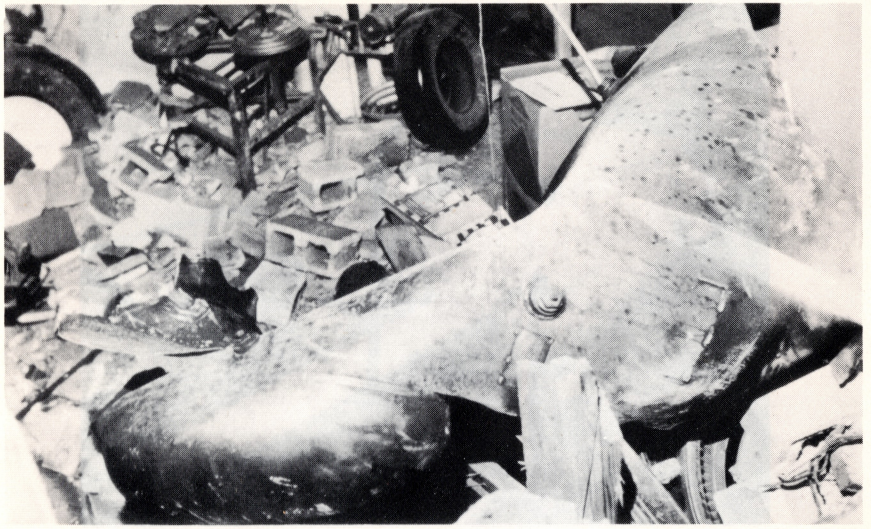
Same tank as above. This example of welding might be acceptable on a plow but not on a pressure vessel. Jurisdictions <u>without</u> Pressure Vessel Laws are subject to this type of product being sold in their area.



Air compressor with three cylinder compressor mounted on top.

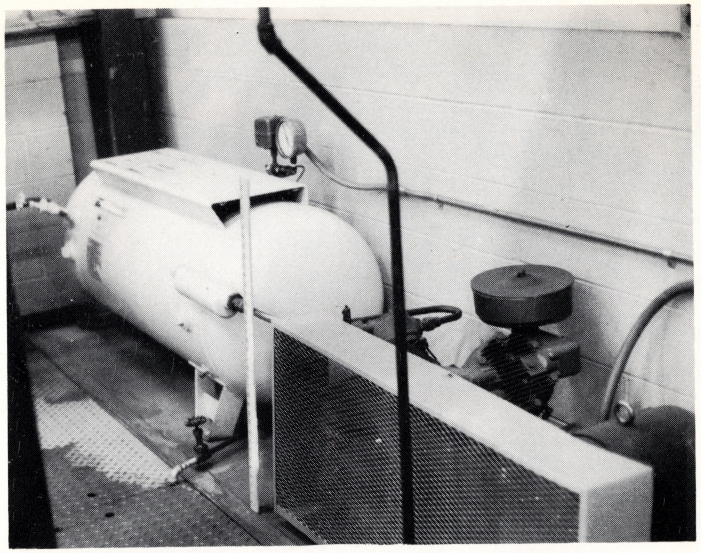


Air compressor with electric driven compressor on top.

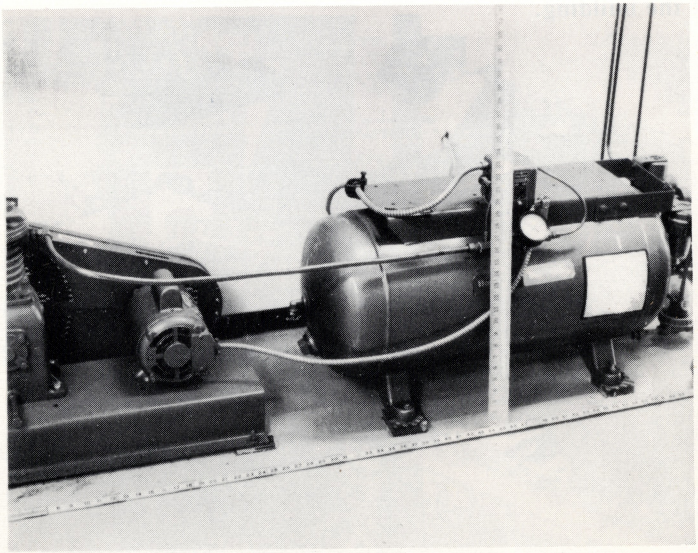


Initial invesigation indicated that a crack propagated from a fillet weld joining a support to an air tank travelled to the head weld joint and continued circumferentially for 38 inches, bending the cyclindrical receiver into this totally different shape with an explosive force that literally tore through the roof of the building.

This air receiver exploded in a tire recapping plant apparently because of a crack propagated from a fillet weld joining a support to the tank, among the results being a hole in the roof big enough to drive a truck through.



Air tank showing compressor mounted on floor instead of tank, a recommended method.



Another tank with compressor mounted on floor. This simple alteration could prevent property damage and personnel casualties as well as providing a long and useful life to the air tank.